

USE OF PRESTRESSED PRECAST SHAFT SUPPORTS, BANNER MINE, LORDSBURG, N. MEX.

BY ALLEN D. LOOK AND LUDLOW G. ANDERSON

* * * * * **Information Circular 7775**



UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary
BUREAU OF MINES
Marling J. Ankeny, Director

Work on manuscript completed July 1956. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is made: "Reprinted from Bureau of Mines Information Circular 7775."

February 1957

USE OF PRESTRESSED PRECAST SHAFT SUPPORTS,
BANNER MINE, LORDSBURG, N. MEX.

by

Allen D. Look^{1/} and Ludlow G. Anderson^{2/}

CONTENTS

	<u>Page</u>
Introduction and summary	1
Acknowledgment	1
General information	1
Geology and physical characteristics of the ore	2
Bonney shaft	2
Details of precast, prestressed concrete sets	3
Size and weight	3
Casting	3
Assembly and pretensioning of blocking beams	7
Installation procedure	7
Conclusions	15

1/ District health and safety supervisor, Bureau of Mines, Duluth, Minn.

2/ Mining health and safety engineer, Bureau of Mines, Phoenix, Ariz.

ILLUSTRATIONS

<u>Fig.</u>	<u>Page</u>
1. Preparing form for casting wallplate	4
2. Plan view of shaft-set assembly showing location of blocking and side view of prestressed wallplate with stressed-steel rod through plate	5
3. End view of shaft-set installation, method of blocking sets, guide installation, and rock bolting	6
4. Special cast 8- by 8- by 8-inch block on assembly table for making blocking beams	8
5. Blocking beam assembled showing tensioning of rods through transverse holes filled with grout	8
6. End view showing installation of bearer beams and securing of shaft sets on bearer beams	9
7. General assembly of set showing bolted corners, post, hanging bolts, end of stressed-steel rod, and steel-bearing plate in prestressed wallplate	11
8. End view of prestressed wallplate showing recess for end plate, post dowel pin holes, end of stressed-steel rod with high-efficiency nuts and round-steel washer holding rod stress against 4- by 4- by 3/4-inch steel plate	11
9. End view of divider showing keystone-shaped end to fit wallplate	12
10. Keystone-shaped recess in wallplate to fit keystone-shaped end of divider, also hole for tie rod and post-dowel pins	12
11. Divider in place ready for post installation	13
12. Corner of wall and end plate showing angle iron bolted in place and dowel-pin holes for corner-post anchor pins ...	13
13. End view of posts showing reinforcing rods which serve as dowel-pin locks to wallplates, hollow core hole, and felt-bearing pads	14
14. Placing post-protruding reinforcing rods in dowel-pin holes in wallplate with felt pad in place	14

INTRODUCTION AND SUMMARY

Uninterrupted shaft operations are an important economic factor in mine operation, and good shaft support is an important aid in preventing accidents and interruptions. More permanent supports can cut the hazards, costs, and delay incident to replacement of conventional timbers, especially where subject to decay.

Installation of prestressed, precast concrete shaft supports in 100 feet of shaft at the Banner mine, Lordsburg, N. Mex., gave a satisfactory permanent installation in a section of shaft that had given trouble with conventional timbering. Use of rock bolts supporting gunited wire netting around the rock walls of the shaft prevented sloughing.

No attempt was made in this paper to arrive at comparative costs of installation of various types of support. However, it was indicated that use of a lighter weight aggregate would be desirable in further use of prestressed precast members as placed in the Banner mine.

ACKNOWLEDGMENT

Acknowledgment and thanks for assistance in the preparation of this paper are due to E. S. Bowman, president, and Frank Bowman, chief clerk, Banner Mining Co., Lordsburg, N. Mex.; and Robert A. Elgin, president, Elgin Corp., Silver City, N. Mex. Acknowledgment is made also of the assistance given by John P. Harmon, mining health and safety engineer, Bureau of Mines, Phoenix, Ariz.

GENERAL INFORMATION

The Banner mine of the Banner Mining Co. is in the Virginia Mining District of southwestern New Mexico about 5 miles southwest of Lordsburg, Hidalgo County, N. Mex. The mine produces about 235 tons per day and employs approximately 75 men underground, 24 men on the surface, and 7 men in a supervisory capacity.

The Virginia Mining District comprises a large area 3 to 10 miles southwest of Lordsburg, N. Mex., in the Pyramid Mountains. Prospecting in this area was begun about 1870, but it was not until the railroad was built into Lordsburg in 1881 that appreciable development began. A smelter was built the same year 2 miles south of Lordsburg and the following year (1882) a 20-stamp mill was completed.

In 1913 a railroad spur was built from Lordsburg to the townsite of Valedon to develop the "85" mine, which is about 2 miles north of the Banner mill by graveled highway and is the loading point for the mine concentrates at present. The "85" mine was shut down during the depression and has not been reopened to the time of this writing.

The Banner Mining Co. acquired 650 acres (12 patented and 29 unpatented claims) in the spring of 1935. Rehabilitation work was started soon thereafter. The ore from the top 5 levels was extracted by former operators and lease holders, and the Banner Mining Co. began development on the 600-foot level. The Bonney shaft was sunk vertically to the 13th level with levels at approximately every 135 feet and numbered consecutively. The elevation of the shaft collar is 4,690 feet; it has been sunk to a depth of approximately 1,440 feet. The Banner property now includes the entire length of the Banner vein, the Miser's Chest vein ($3/4$ mile away), and a number of smaller fissures - over 2,000 acres.

GEOLOGY AND PHYSICAL CHARACTERISTICS OF THE ORE

According to Youtz,^{3/} all the rocks of the Virginia district are of igneous origin and consist chiefly of andesite, diorite, and porphyries of similar composition. A coarse-grained, light-color grandiorite intrudes the andesite and diorite from below. Three separate fracture systems traverse these rocks. The earliest system and the most important economically has a N. 40° to 45° E. strike, and a later system striking from N. 75° E. to due east cuts the first. The veins of the district are mineralized fault fissures belonging to these two systems.

BONNEY SHAFT

The Bonney shaft formerly was used for the downcast ventilation shaft but now is used for the upcast or exhaust air from the mine. The temperature and humidity of the exhaust mine air were quite high and tended to increase the rate of decay considerably in the shaft timber to such an extent that it was necessary to constantly replace timber sets.

Sloughing of sidewalls in certain sections of the shaft has also presented problems of hazard and expense.

The Bonney shaft was equipped with an 81-foot steel headframe and had 3 compartments; 2 compartments were used for hoisting ore, men, and supplies; the third compartment was used for a manway and for service lines. It was served by a 2-drum hoist converted from steam to electric power with a 200-hp. motor. Hoisting rope was 1-1/8-inch improved plow-steel cable.

Owing to the excessive cost of maintenance, the hazards involved by the continued use of conventional timber, and the planned increase in ore tonnage to be hoisted through the Bonney shaft, it was decided to install a test section of precast, prestressed concrete members from the 500-foot to the 400-foot level, which is through poor ground and has caused considerable trouble in the past.

A second experiment tried in this section of shaft was the use of rock bolts supporting wire netting around the rock shaft walls. Guniting of variable thickness was then blown over the rock bolts and wire netting to protect the wall rock from sloughing due to moisture and air action. The sidewalls were thoroughly scaled before wire netting and rock bolts were installed. This process eliminated the necessity for lagging around the concrete sets.

^{3/} Youtz, Ralph B., Mining Methods at the Eighty-Five Mines, Calumet and Arizona Mining Co., Valedon, N. Mex.: Bureau of Mines Inf. Circ. 6413, 1931, pp. 2-4.

DETAILS ON PRECAST, PRESTRESSED CONCRETE SETS

Prestressed concrete is placed in a permanent state of compression greater than any tensile stresses it will carry under load because it has the reinforcing tensioned. Prestressed concrete is now accepted among standard building materials and is competitive with reinforced concrete and structural steel. At the Banner mine prestressed concrete was more suitable than reinforced concrete, since less steel and concrete would be used and hence less dead weight would be handled. In addition, it would be crack-free and have greater elasticity.

Size and Weight

Each set was comprised of the following members:

<u>Number</u>	<u>Description</u>	<u>Size</u>	<u>Weight each, lb.</u>
Two	Wallplates	6" x 5" x 14' 9"	475
Do.	End plates	6" x 5" x 5' 1"	163
Do.	Dividers	6" x 5" x 5' 1"	163
Eight	Posts	6" x 6" x 7' 1"	250

The total weight per set was about 3,750 pounds.

Casting

Each member (refer to table above) was cast in an assembled iron form (see fig. 1) specially designed for each member to assure accurate placing of reinforcing rods, holes for steel tensioning bars, pinning posts to wallplates, hanging bolts, angle-iron bolts, and for standard sizing and accurate framing. After the forms were poured, vibrators were used to cause proper settling and filling. End plates and dividers were cast solid with four 1/2-inch reinforcing rods spaced in each corner about 1 inch in from the surface (see fig. 2). Posts were cast with a 2-inch hollow center (see fig. 13) and four 1/2-inch reinforcing rods spaced the same as in spreaders and end plates. Two of the rods extended about 1 inch out from the ends to serve as dowel pins to secure the posts to the wallplates (see figs. 2, 3, 13 and 14).

Specially prepared high-strength steel bars 5/8 inch in diameter and 15 feet 6 inches long were placed in the 7/8-inch hollow corehole through the precast wallplate. Steel bearing plates 4- by 4- by 3/4-inch with a 7/8-inch-diameter hole in the center were then placed over the steel bars in contact with the end of the precast wallplates. A heavy 5/8-inch steel washer was then placed against bearing plates and a 5/8-inch high-efficiency nut with tapered threads was turned on to the end of the bar. The bars were provided with a long tapered thread on one end and a short tapered thread on the other end (see fig. 8). The nut bearing on the washer at one end was tightened with a conventional wrench after which a specially designed hydraulic jack was fastened to the long threaded end of the stress-steel bar and pressure applied against the 4- by 4- by 3/4-inch bearing plate.

An internal stressing force of 30,600 p.s.i. was applied by the hydraulic jack, and the bearing-plate nut on this end was tightened securely to permanently lock the pressure of the bar against the plates. During the stressing operation the bar was elongated approximately three quarters of an inch. When this internal stress was applied, the plastic flow or compressibility of the concrete ceased after a short period of time, and the wallplates retained a permanent compression of approximately

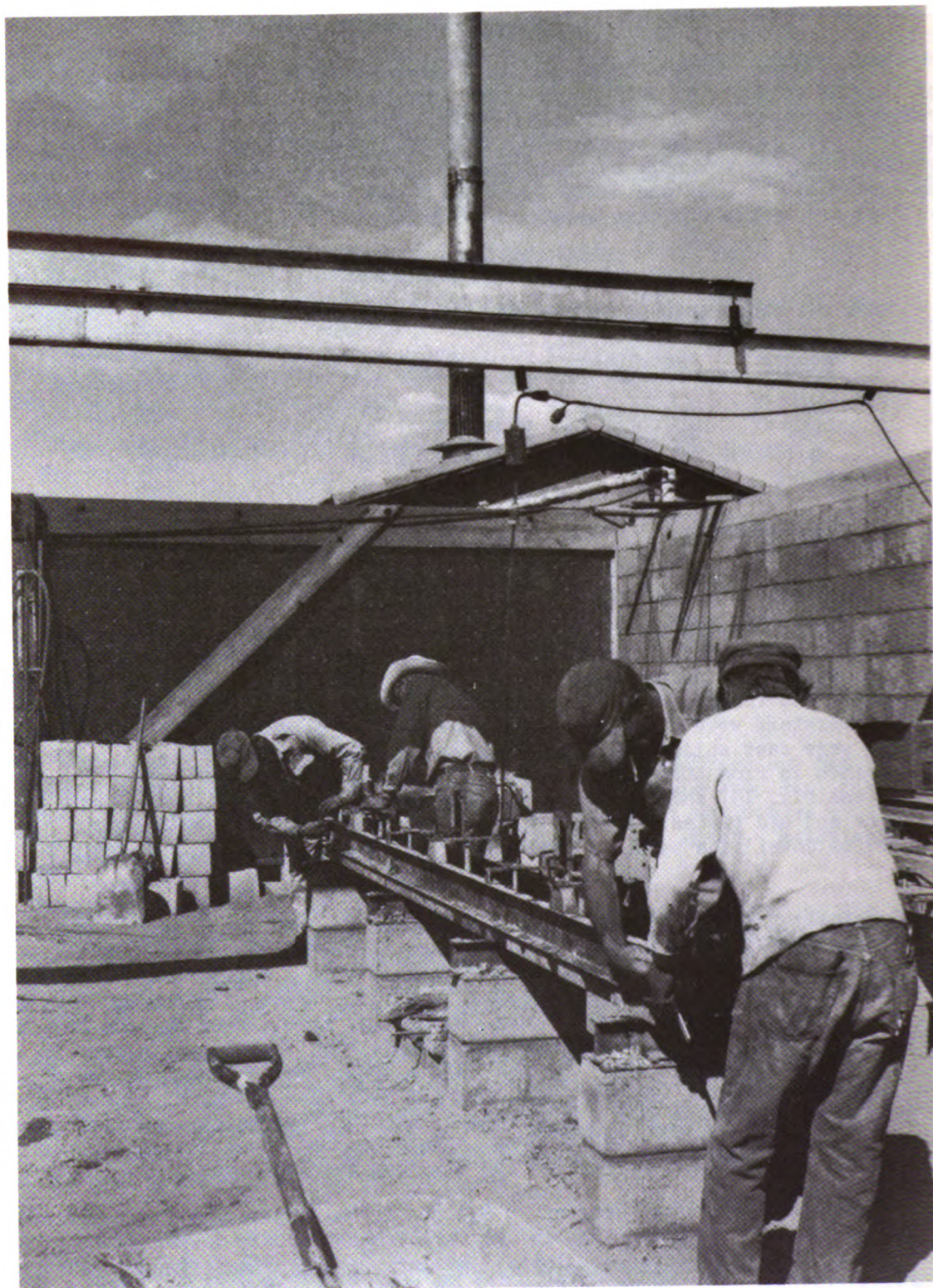


Figure 1. - Preparing form for casting wallplate.
(Courtesy, Elgin Corp.)

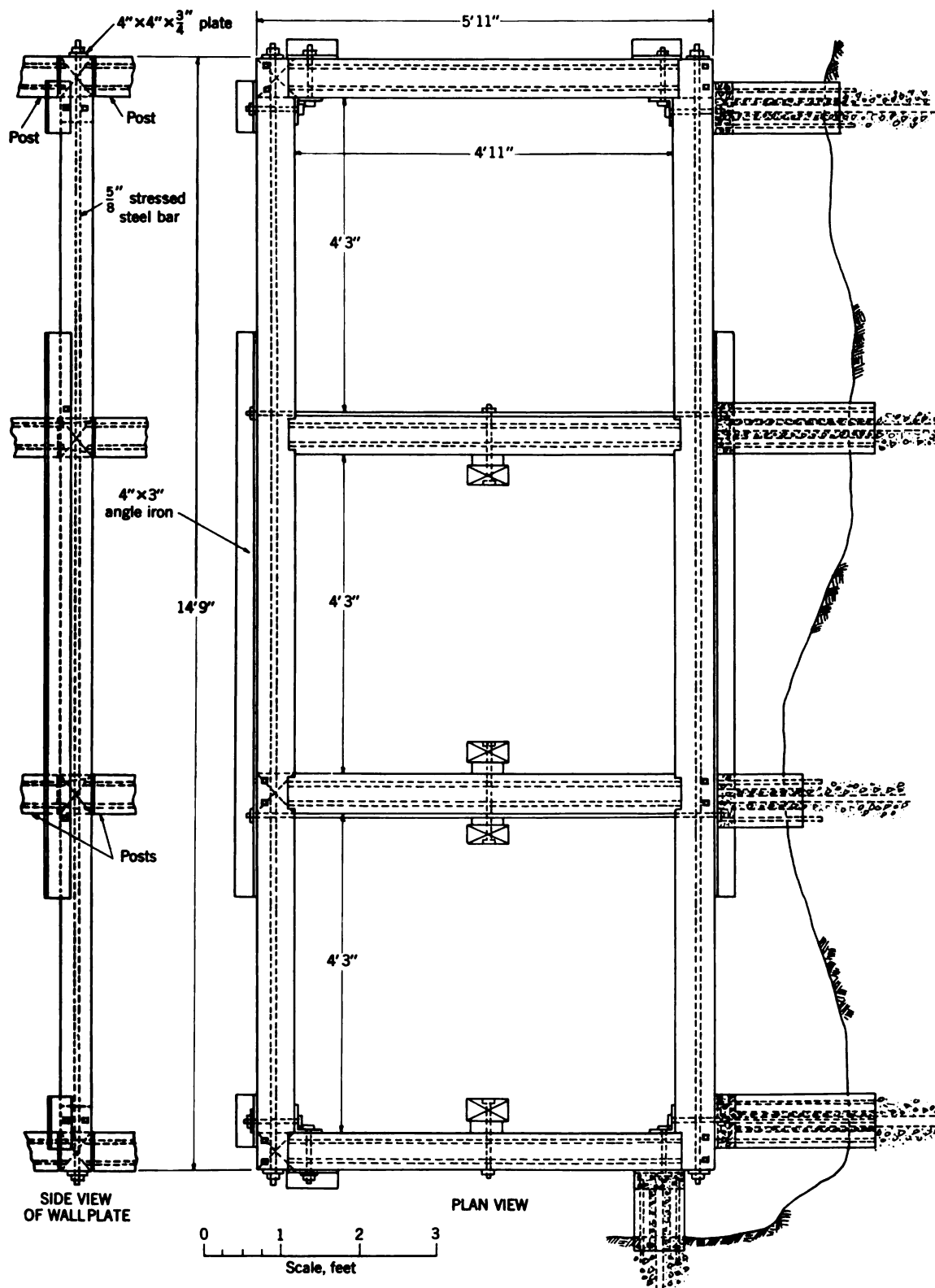


Figure 2. - Plan view of shaft-set assembly showing location of blocking and side view of prestressed wallplate with stressed-steel rod through plate.

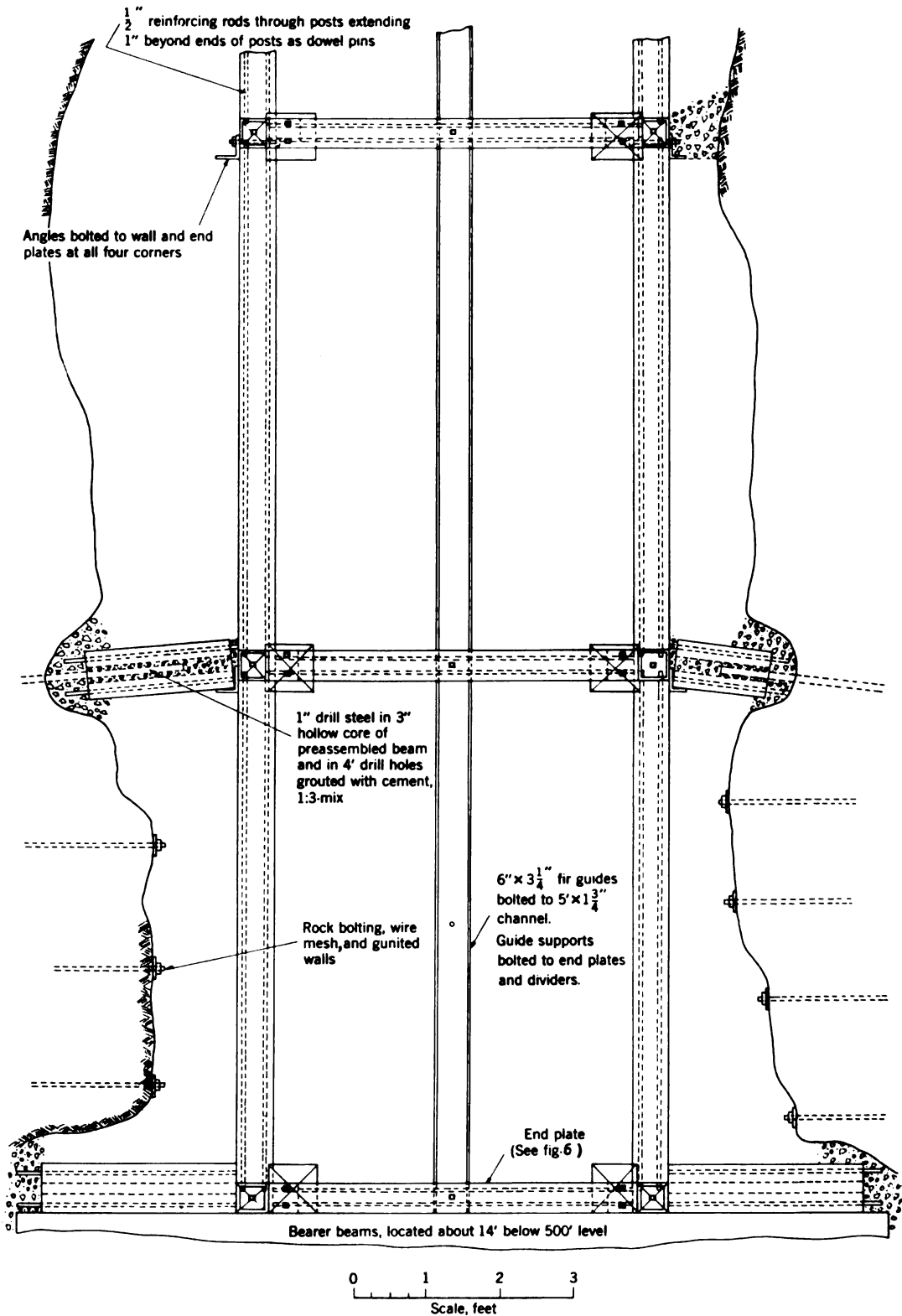


Figure 3. - End view of shaft-set installations, method of blocking sets, guide installation, and rock bolting.

26,000 p.s.i. Since the stress bar is free through the member, the pressure of the stress bar on the end plates is transferred through the member. After prestressing, the characteristics of the concrete members were entirely changed. They became flexible and highly resistant to lateral forces and can, therefore, be subjected to heavy loads or forces and will spring back to their original position without fracture when these loads or forces are removed.

All members are designed for 4,000 p.s.i. concrete; a 28-day test showed an excess of 5,000 p.s.i. Stress-steel bars and other metal parts are treated with a heavy coating of asphalt for protection against rusting or deterioration.

ASSEMBLY AND PRETENSIONING OF BLOCKING BEAMS

Blocking beams for concrete sets were made of special 8- by 8- by 8-inch building blocks with a 2- by 3-inch center core and 3 1/2-inch transverse holes cast about 1 inch from the upper and lower edges, 1 hole at the top and 2 at the bottom (see fig. 4). The assemblies were made on a steel table with mortar between the joints of the blocks and were pretensioned with threaded rods through the transverse holes. The rods were tensioned by using steel plates at each end of the assembly and tightening the nuts against the plates (see fig. 5). The rods were next grouted into the assembly by forcing pure cement grout through the transverse holes, thus completely cementing the rods in the beams and protecting them from corrosion. After the cement grout took on a permanent set, the external plates were removed. The tensioning was locked into the assembly by the grout, and the rod tension could not be released without destroying the assembly.

INSTALLATION PROCEDURE

The first step before the precast, prestressed concrete members were installed was to select a suitable place to install 4 preassembled, pretensioned 8- by 16-inch (in cross section) bearer beams (see fig. 6). The place selected was approximately 14 feet below the 500-foot level. The old timbers were removed and the shaft walls scaled. Bearing notches about 2 to 3 feet in depth were cut in the sidewalls of the shaft for each bearer beam so that they could be installed to allow the end plates and dividers to be positioned level on the same plane and parallel on their surfaces (see fig. 6).

The 4 bearer beams were 8 inches by 16 inches by 12 feet. They were made with three 3-inch hollow cores and four 1/2-inch reinforcing rods protruding about 12 inches from each end for ties into the end concrete after being positioned in the shaft (see fig. 6). The top and bottom hollow-core holes were filled with concrete after 3/4-inch rods were placed in them from each end just before positioning the beam; likewise, a 1-inch rod was placed in the center hollow core at each end and grouted in. Three holes were drilled into the center with 1-inch drill steel and 1 drilled from 7 to 8 inches above and below the center of the recess in the sidewalls of the shaft to a depth of 5 to 6 feet. One-inch drill steel was grouted into these holes and allowed to protrude to a maximum distance, so as not to interfere with the positioning of the bearer beam. When the bearer beam was lowered in place, the rods in the center hollow-core hole were pulled out to protrude as far as possible into the end areas to be concreted. One-inch drill holes were also drilled in notches in the sidewalls of the shaft directly under and about 5 feet down from the base of the bearer beam. These holes were drilled to a depth of about 4 feet and at a plus- or minus-30° angle. A preassembled, pretensioned 8-inch beam of proper length was placed on end in this notch, and a 1-inch drill steel of proper length to extend from the bottom of the drill hole to several inches above the top of the

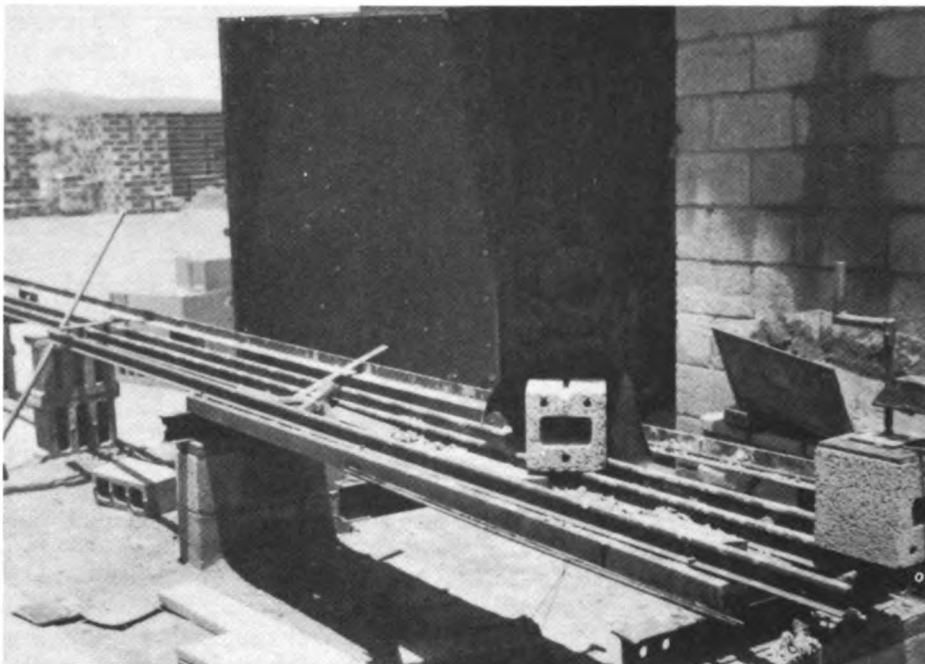


Figure 4. - Special cast 8- by 8- by 8-inch block on assembly table for making blocking beams.

(Courtesy, Elgin Corp.)

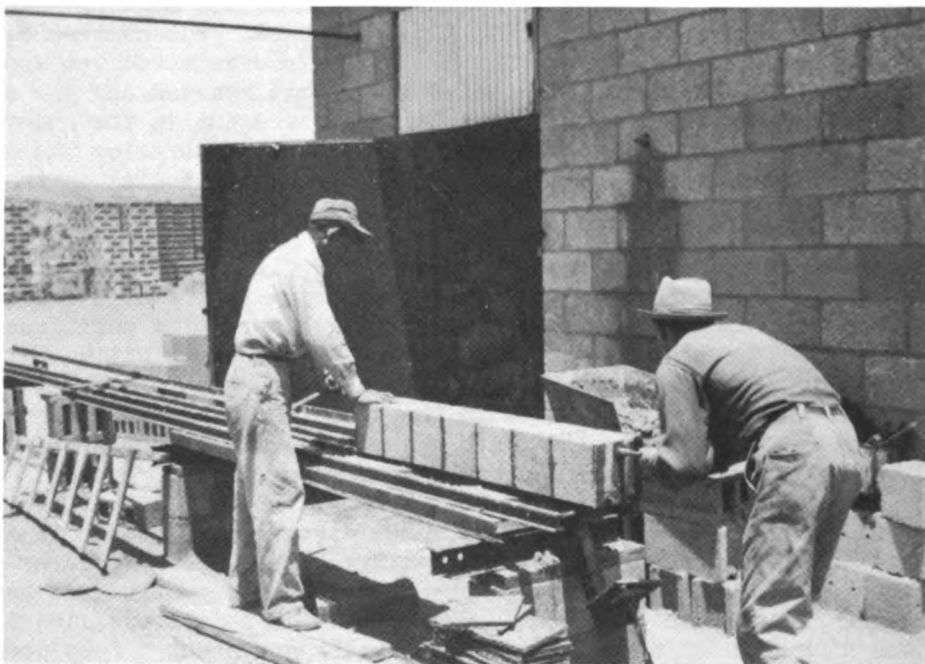


Figure 5. - Blocking beam assembled showing tensioning of rods through transverse holes filled with grout.

(Courtesy, Elgin Corp.)

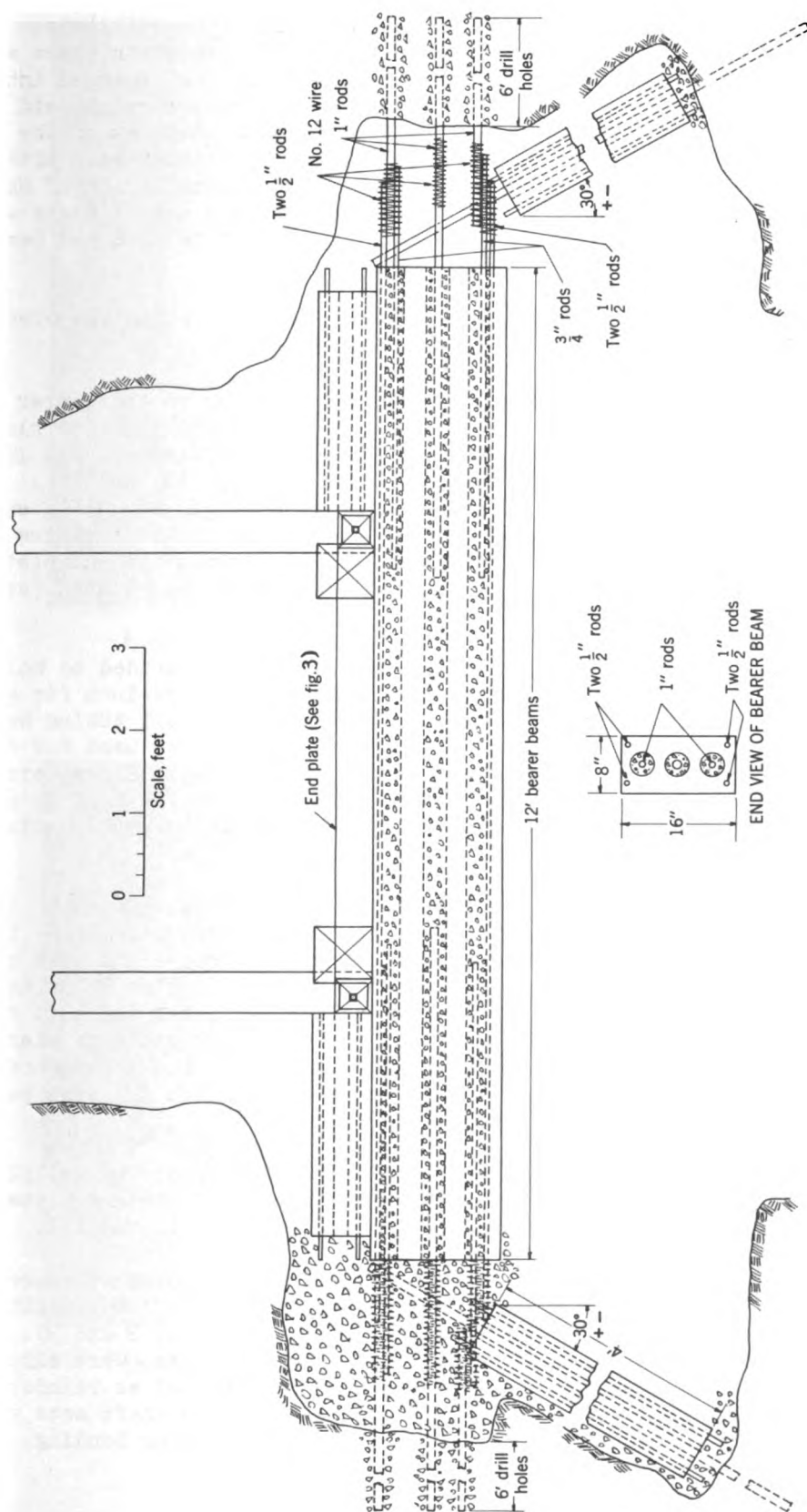


Figure 6. - End view showing installation of bearer beams and securing of shaft sets on bearer beams.

beam was placed through the hollow core of the beam and into the drillhole. The drill steel in the drillhole and the base of the beam were grouted in place and the hollow corehole filled with cement. The bearer beam was then lowered into position and No. 12 wire used to tie all protruding rods together and to aid in reinforcing the concrete ends. Forms were then built around the ends of the beams to the recesses in the sidewalls and filled with a 1:3 mix of concrete. After the concrete at the ends of the bearer beams had a proper set, installation of the concrete shaft members was begun (see fig. 6). Bearer beams from actual tests were capable of supporting about 18 tons each, and the total possible load per bearer beam was approximately 6-1/2 tons.

The old timber was removed, shaft walls were scaled, rock bolts and wire netting were installed, and gumite was applied (see fig. 3).

Wallplates and end plates were placed in a level position on the bearer beams and securely blocked and concreted in place (see figs. 2, 3, and 7). End plates fit into 1-inch recesses cast in wallplates (see fig. 8), and dividers fit into 1-inch keystone-type recesses cast in wallplates (see figs. 9, 10, and 11). Two tie rods are used, one on the outside of each divider (see figs. 2 and 7), and the wallplates are cast with an arch so that pressure is brought on the dividers when the ends of the wallplates are drawn in by means of bolts to fit the end plates. This is done by placing bolts through 4- by 4-inch angle irons and plates (see figs. 2 and 12).

Holes through the center of end plates and dividers were provided to bolt 5- by 1-3/4-inch channel guide supports, which secure the 6- by 3-1/4-inch fir guides in place (see figs. 2 and 7). One 1/2- and one 3/4-inch thin-wall tubing case in ends and sides of wallplates opposite dividers and end plates were used for dowel-pin holes to secure posts to wallplates (see figs. 8, 11 and 14). Heavy tarred felt was used on all post joints to compensate for any irregularities that might occur in the casting of the members. All joints were heavily tarred to prevent rusting of metal parts (see figs. 13 and 14).

Steel plates 4 by 4 by 3/4 inches at ends of wallplates were used to transfer tension from bars to compression through precast concrete wallplates. A 4- by 3-inch angle, 8 to 10 inches long, was bolted to the bottom corner-angle bolt on the outside at the ends of each wall and end plate and extended 2 inches below the bottom of the plates to support concrete blocking and aid in securing the sets in place (see figs. 2 and 3). The same size angle, 7 feet 6 inches long and some places longer, extending 2 inches below the wallplate was centered on the outside of the wallplates and secured by the tie-rod bolts. These angles served the same purpose in blocking as the outside end angles (see fig. 2).

The posts also served to lock end plates and dividers in place on wallplates because the 6- by 6-inch posts extended 1 inch over the ends of the end plates and dividers where they were recessed into wallplates (see figs. 2, 11 and 14).

All blocking beams were placed at a slight angle from the concrete members down to the shaft walls to enable each blocking beam to support part of the weight of the concrete shaft members as well as to hold the alignment (see figs. 2 and 3). The 1/2-inch reinforcing tensioned rods, grouted in the blocking beams, were allowed to protrude as far as possible into the end grouting areas and served as reinforcement in the grout and ties to the blocking beams. All surface on the shaft sets was cleaned and roughed around the areas to be grouted to assure proper bonding.

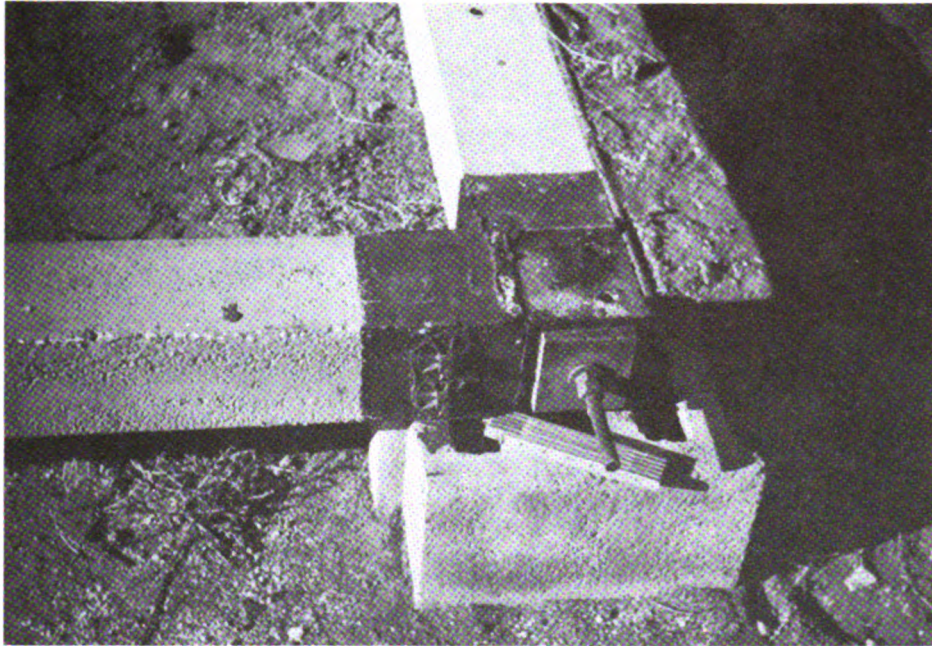


Figure 7. - General assembly of set showing bolted corners, post, hanging bolts, end of stressed-steel rod, and steel-bearing plate in prestressed wallplate.

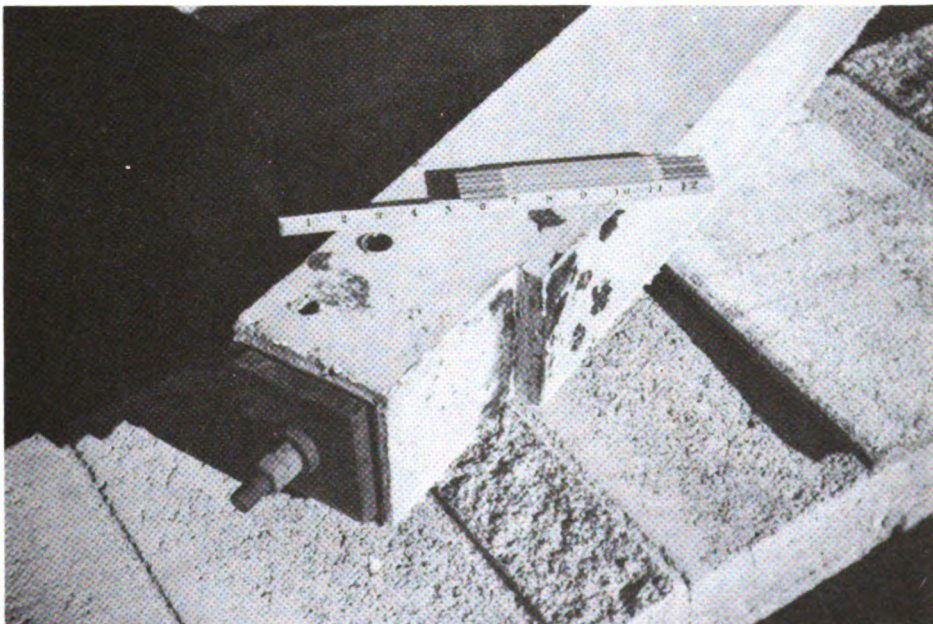


Figure 8. - End view of prestressed wallplate showing recess for end plate, post dowel pin holes, end of stressed-steel rod with high-efficiency nuts and round-steel washer holding rod stress against 4- by 4- by 3/4-inch steel plate.



Figure 9. - End view of divider showing keystone-shaped end to fit wallplate.

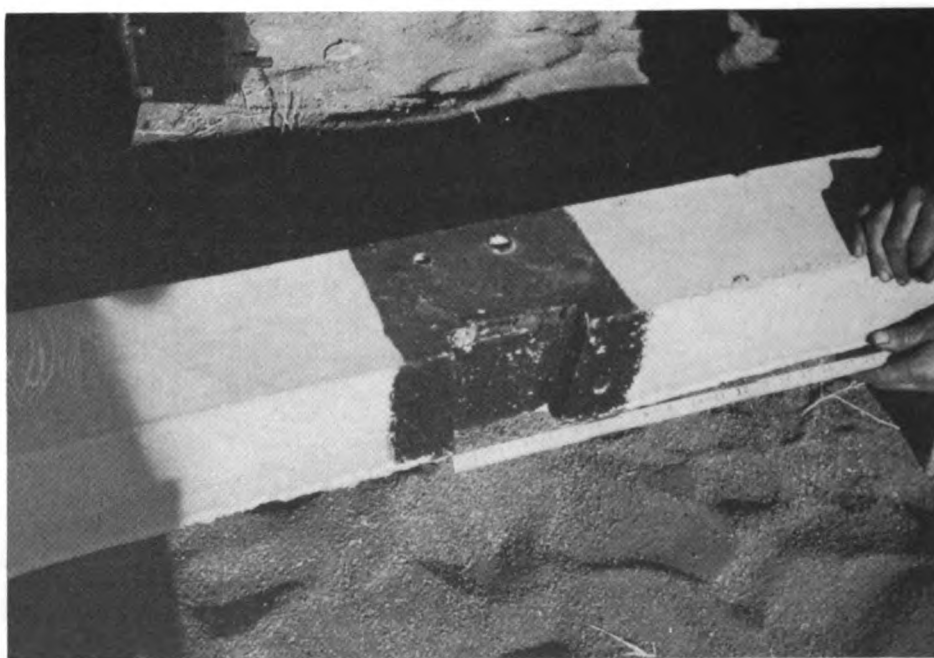


Figure 10. - Keystone-shaped recess in wallplate to fit keystone-shaped end of divider, also hole for tie rod and post-dowel pins.

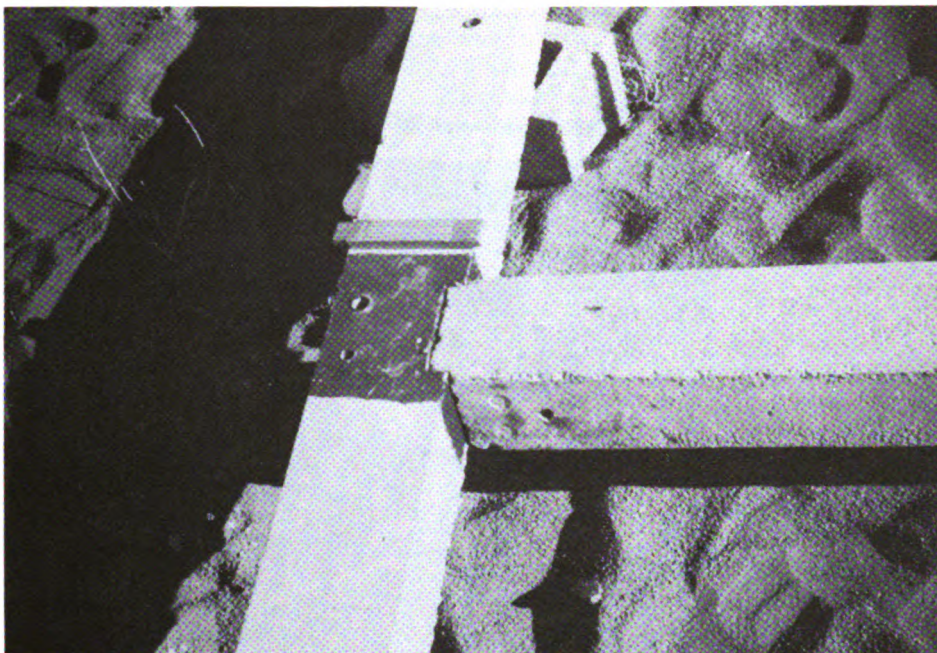


Figure 11. - Divider in place ready for post installation.

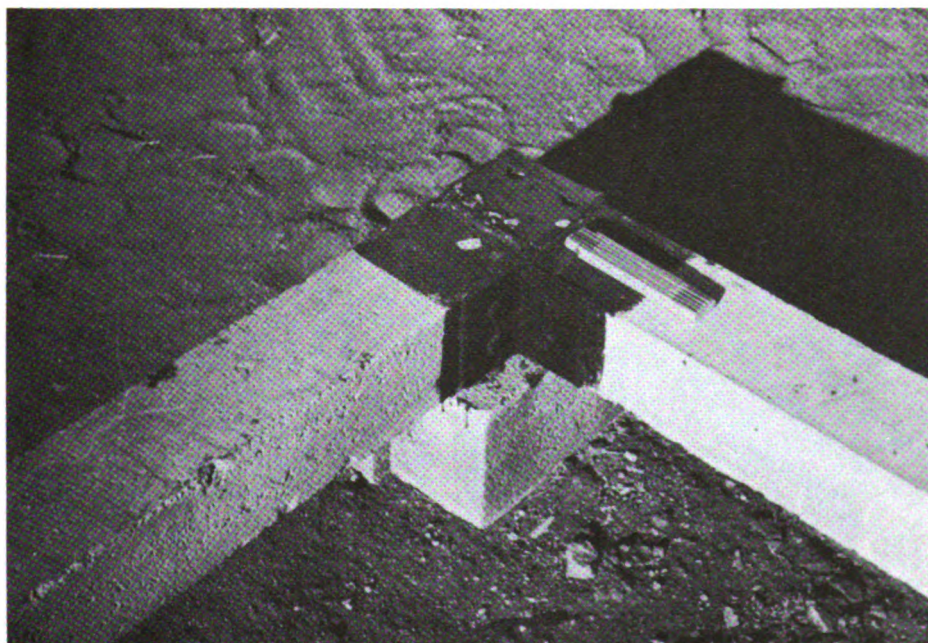


Figure 12. - Corner of wall and end plate showing angle iron bolted in place and dowel-pin holes for corner-post anchor pins.

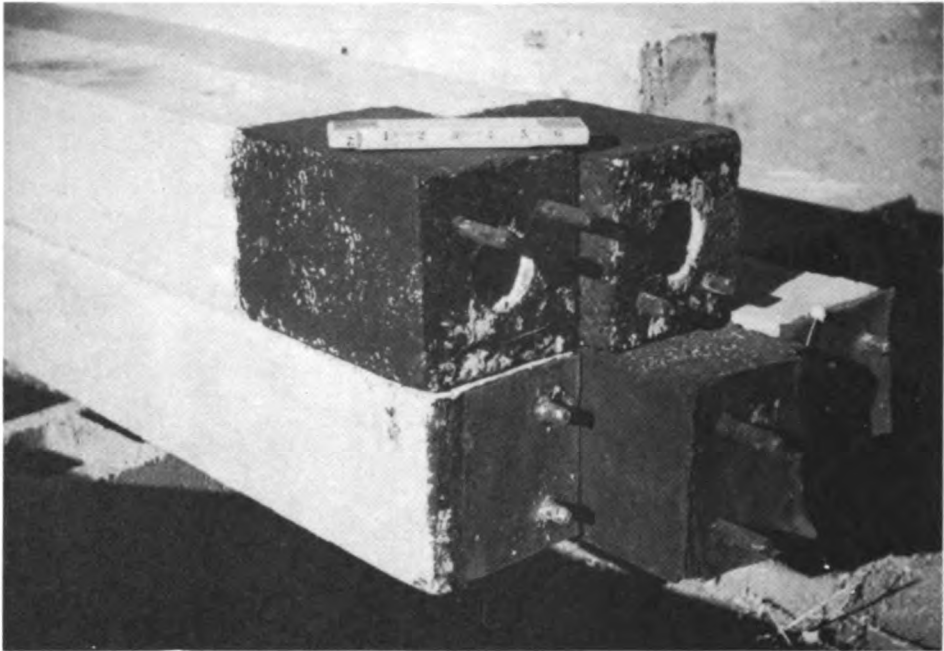


Figure 13. - End view of posts showing reinforcing rods which serve as dowel-pin locks to wallplates, hollow core hole, and felt-bearing pads.

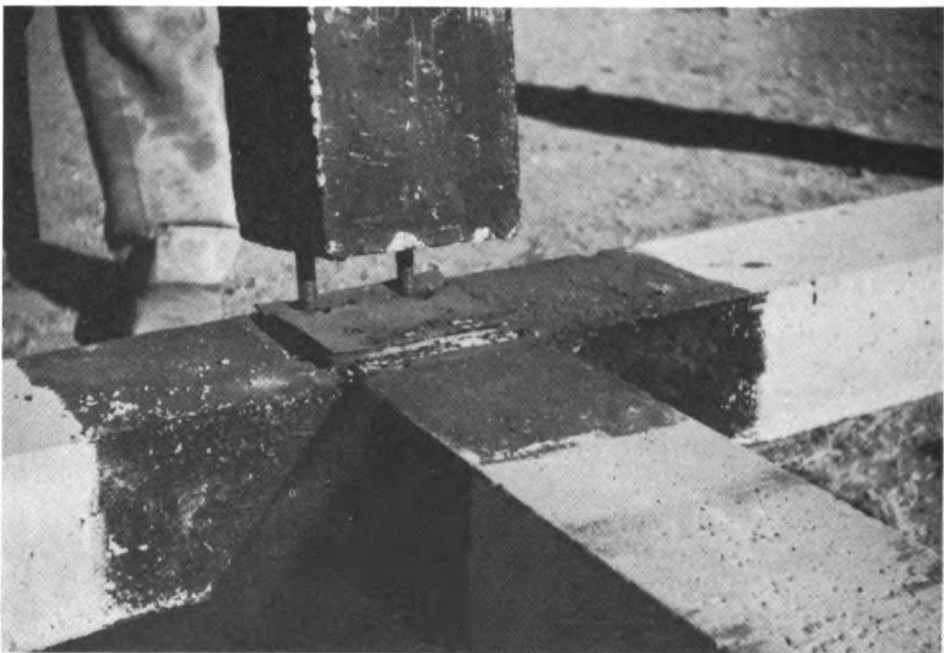


Figure 14. - Placing post-protruding reinforcing rods in dowel-pin holes in wallplate with felt pad in place.

The maximum distance from the walls of the shaft to the precast shaft sets was about 12 feet, and the minimum distance was a few inches. Twelve blocking beams were used to a set when distance to walls was 12 or more inches - 4 on each side and 2 on each end (see fig. 2). When distance to wall was less than 12 inches, metal forms were built and filled with concrete (see fig. 3).

The blocking beams were positioned with the two 1/2-inch reinforcing rods on the bottom and the one 1/2-inch reinforcing rod on the top side. Forms of light-weight metal were built around the base and sides of the blocking beams and completely encased the wallplate and post at points of junction to hold the concrete grout in place until the grout had time to properly set.

Two 3/4-inch hanging bolts were used on each side between wallplates in the end compartment.

CONCLUSIONS

1. The shaft walls are stabilized, and sloughing is prevented by the use of wire netting that is secured by rock bolts and gunited.
2. The concrete shaft members installed in this shaft are permanent and eliminate many of the hazards resulting from decay and failure of conventional timber.
3. The hazardous work of retimbering is eliminated in the area where concrete shaft members and gunite are used.